ARTEMIS: A Collaborative Framework for Health Care

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Patient centered healthcare delivery is an inherently collaborative process. This involves a wide range of individuals and organizations with diverse perspectives: primary care physicians, hospital administrators, labs, clinics, and insurance. The key to cost reduction and quality improvement in health care is effective management of this collaborative process. The use of multi-media collaboration technology can facilitate timely delivery of patient care and reduce cost at the same time. During the last five years, the Concurrent Engineering Research Center (CERC), under the sponsorship of DARPA (Defense Advanced Research Projects Agency, recently renamed ARPA) developed a number of generic key subsystems of a comprehensive collaboration environment. These subsystems are intended to overcome the barriers that inhibit the collaborative process. Three subsystems developed under this program include: MONET (Meeting On the Net) - to provide consultation over a computer network, ISS (Information Sharing Server) - to provide access to multi-media information, and PCB (Project Coordination Board) - to better coordinate focussed activities. These systems have been integrated into an open environment to enable collaborative processes. This environment is being used to create a wide-area (geographically distributed) research testbed under DARPA sponsorship, ARTEMIS (Advance Research Testbed for Medical Informatics) to explore the collaborative health care processes. We believe this technology will play a key role in the current national thrust to reengineer the present health-care delivery system.

INTRODUCTION

Patient centered healthcare delivery is an inherently collaborative process involving a wide range of individuals and organizations with diverse perspectives: primary care physicians, hospital administrators, laboratories, clinics and insurance. Together, all participants collaborate to deliver quality care at a reasonable cost. Figure 1 depicts a view of this system from the perspective of the patient. In the center of the system, the patient can receive care from a combination of *players* in the next three rings (i.e., by an individual physician, a physician group or an institution). The activities of the participants in these rings are influenced by the participants in the next two rings: the payers and the information resources. The outermost ring constitutes the "glue" that binds the national (Government) system. This includes the communication networks, national information resources such as the National Library of Medicine (NLM), research establishments such as the Centers for Disease Control (CDC) and national directives for health care privacy, quality and cost. The key to cost reduction and quality improvement in health care is effective management of this collaborative process.

During the last five years, the Concurrent Engineering Research Center (CERC), under the sponsorship of DARPA (Defense Advanced Research Projects Agency, recently renamed ARPA) developed a number of key subsystems of a comprehensive collaboration environment [1]. These subsystems are intended to overcome the barriers that inhibit the collaborative process. In our current and remaining phases in the ARPA program (three years and 10 Million dollars) we are applying these collaborative technologies to the health care domain.

In the next section we discuss briefly collaborative technologies. In the following section we discuss the current status of our evolving health care domain testbed: ARTEMIS. We conclude with our goals and plans for this testbed under the ARPA program.

COLLABORATION TECHNOLOGY

To support the fundamental day-to-day activities of a person working in a team, one can envision a variety of services. At CERC, we have developed generic technology that support collocation, information sharing and coordination. These services are described briefly below.

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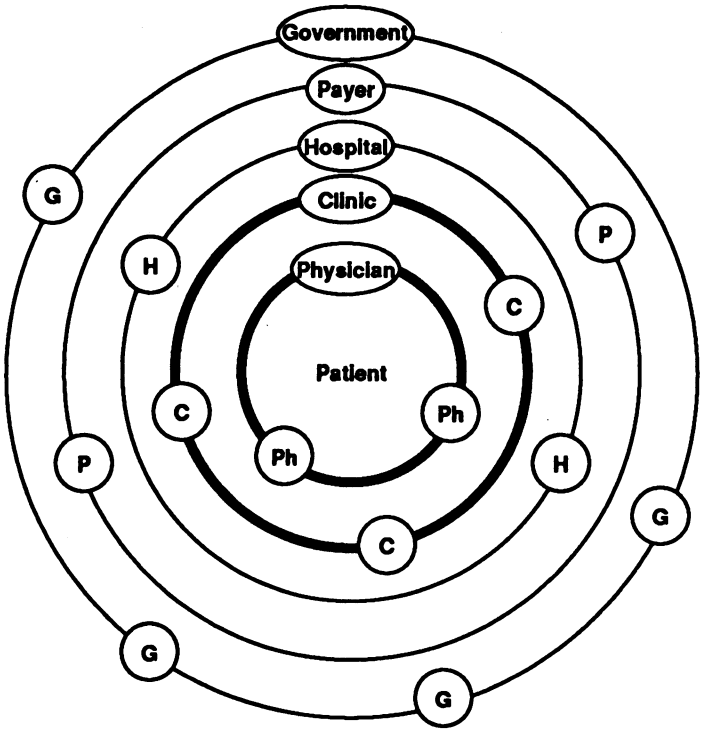

Figure 1. Patient centric view of the health care system

Collocation services: When we require people who are geographically dispersed to meet at the same location, significant travel time, money, and energy of the participants are spent, leading to decreased productivity. Moreover, in most meetings and conferences, the participants are not equipped with all the information they might need to function effectively. In other words, they are dislocated from their ideal work environment. Furthermore, some meetings are totally unstructured and free form which diminishes their effectiveness. Finally, many of these meetings have no good mechanisms to archive all the events that occur for future use.

The solution is to use existing computer and communications technology to overcome the distance barrier. Overcoming this distance barrier cannot only cut travel costs and travel time, but it can also increase productivity by enabling individuals to participate in conferences and meetings from the office or home. The metaphor we envisage here is "bring your office to your meetings."

One solution to overcoming the distance barrier is based on a computer-based, real-time multimedia conferencing system to facilitate collocation of people and programs, thereby providing a tool for effective communication and cooperation among multiple participants over a computer network. Such systems are also known as *desktop conferencing systems*. We believe such a system will be a significant advantage for providers in scenarios, such as consultation, and grand rounds. We intend to use a desktop conferencing system developed at CERC called Meeting On The NETwork (MONET)[2]. MONET provides multimedia conferencing capability at various levels (text, graphics, voice and video) depending on the bandwidth available. It also provides a facility for archiving minutes of a meeting as well as sharing computer applications by several people.

People can effectively communicate in person and in face-to-face meetings because they can see each other, notice each other's facial expressions, hear each other's voices clearly and use blackboards and other media to draw pictures, take notes and point to things. Since effective communication is crucial for cooperative work, systems that provide computer support for cooperative work should provide an environment that emulates face-to-face meetings.

Coordination services: Traditionally, coordinating any task has been largely a human process. Coordination is critical for effective functioning of a team of health care professionals working on a patient providing different kinds of care. We have developed a system called the Project Coordination Board (PCB) that provides a number of services useful for effective col-

laboration among health care professionals. These services provide computer support for group decision-making over a geographically dispersed network. In particular, common visibility of activities and data, planning and scheduling of activities, progress tracking, tracking a patient record and flow of related information, change notification, and constraint management across multiple perspectives are some of the services provided by this system.

Information services: Information in an enterprise is stored in heterogeneous data formats and in various legacy databases and file systems scattered across the organization. However, accessing the relevant information in such a heterogeneous setting can be a daunting task. Accessing such information requires a user to know about different communication protocols and the nuances of various databases. After going through all these procedures, the user still has to synthesize the information retrieved from various systems into a coherent whole. We need a system that can provide a team member with a unified view of the distributed information and also can provide uniform and easy access to the information. Information sharing deals with developing common data representations and providing transparent access to information in a distributed heterogeneous system. Problems arising in the management of replicated data, version and concurrency control, and change management in distributed data bases are of concern here. We have developed a tool called the Information Sharing System (ISS) to address this problem [3]. By using the ISS, a provider can concentrate on the information he/she needs from a health care perspective (dietetic information, therapies, encounter data, etc.) rather than worry about where the information is stored.

ARTEMIS

The collaboration technologies described have been integrated into an open environment. Open environments provide clean, easy and intuitive interfaces between new and existing computer systems and also facilitates incremental augmentation of the environment with new tools. Using these modules we are in the process of creating a research testbed, ARTEMIS (Advance Research TEstbed for Health Care Infor-MatIcS) to explore the collaborative health care delivery. Specifically, ARTEMIS is intended to demonstrate the following:

1. Viability of a multimedia patient record handling system that makes accessing patient information as easy as accessing cash through an Automatic Teller Machines.
2. Ability of a General Practitioner to confer with a remotely located specialist using a wide area network.
3. Automated (near paperless) claims processing.
4. Quality assurance via a network-based peer review.
5. Continuing medical education.
6. On-line access to "medical knowledge."
7. Coordination of concurrent activities to reduce duplication of testing etc.
8. Support epidemiological studies.

The wide-area network infrastructure may consist of internet and other national networking initiatives. The specific technologies may include Asynchronous Transfer Mode (ATM), Frame relay, Mobile Cellular and Radio networks and other associated technologies. Existing and newer protocols such as TCP/IP and jitter-free protocols for multimedia transfer can be used at the transport level.

Figure 2 shows the target for ARTEMIS we intend to realize in the current phase of the DARPA program. The configuration of the testbed will link a number of major hospitals, rural hospitals and some primary care physicians in West Virginia.

Multimedia Patient Record Handling System

Once given the network connectivity, we can exploit the ISS and PCB to provide a patient-centered view to health care [4]. The ISS allows us to collate and integrate a particular patient information from a number of different sources - for example from Radiology, Pathology, Clinical labs, Pharmacy etc. The technology needed to interface and extract from a number of different existing systems over a wide-area network is what is routinely demonstrated in our center today.

Figure 3 shows how such patient information could be collated into multi-media hyperlinked folders of information. The key enabler in having such hyperlinked information is heterogenous database integration infrastructure which CERC has already developed. With current technology all information related to a particular patient could be made available in a simple *point-and-click* fashion - the MRI images, CT scans, Biopsy results, audio annotations, heart beats, and EKGs - organized in whatever fashion deemed appropriate by the healthcare practitioner. Figure 3 shows the types of information which a hospital deals with, patient information organized as multi-media folders, a particular patient information based on: Chronology, Diseases, Vital signs, Lab/Radiology, and general information.

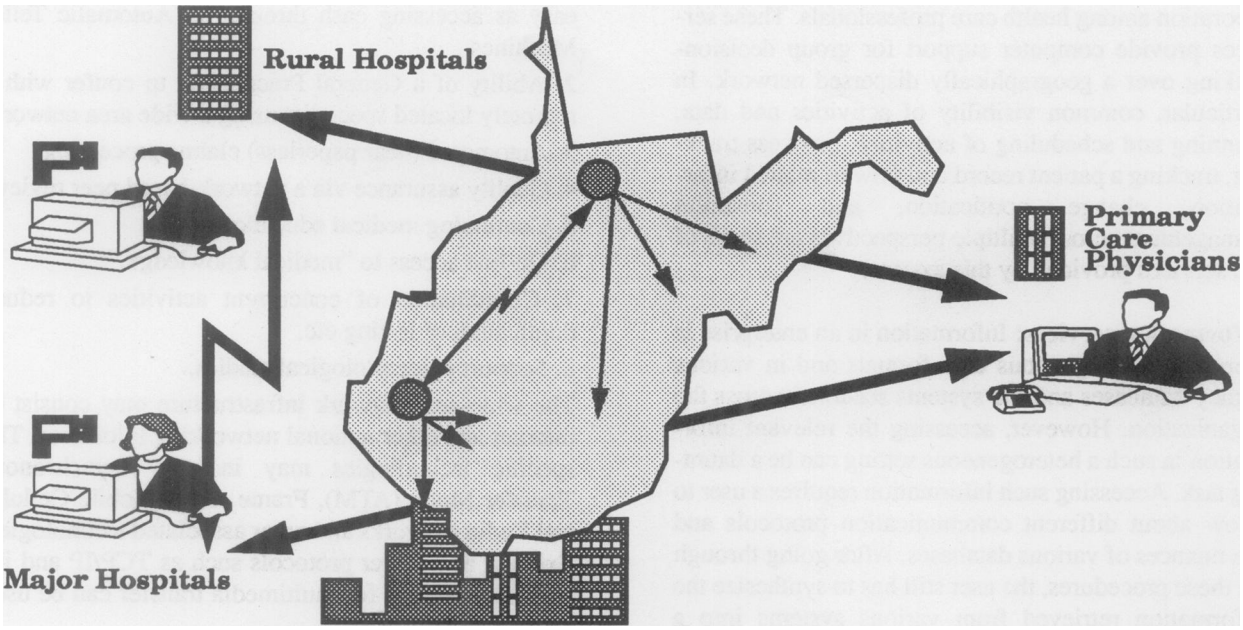

Figure 2. Proposed configuration of ARTEMIS testbed

Remote Consultation using MONET

We intend to use the MONET system to allow physicians to consult and discuss the same patient record in a virtual face-to-face meeting over the network. Physicians see the same patient information on the screen at the same time (a *What-You-See-What-I-See:* WYSWIS interface). For instance, the chronology information and MRI images of a particular patient can be shared, annotated and discussed in real-time.

Conclusions

We are in the process of applying the collaboration technology that was developed under the ARPA program to health care domain. As part of a Statewide Health Information Network (SHINE) initiative we plan to demonstrate this technology by setting up networks between Morgantown, Huntington and Charleston, linking a number of hospitals and clinics - Valley Health Systems (serving the tri-state area of West Virginia, Kentucky and Ohio), Cabell Huntington Hospital, Charleston Area Medical Center, and hospitals and clinics in Morgantown. Also we intend to address assurance of quality, privacy, confidentiality and data integrity.

In summary, we expect the ARTEMIS to serve as a testbed for validating emerging technologies that demonstrate the potential for cost-reduction and quality improvement in providing healthcare. We also plan to leverage the developments in the national information infrastructure (data superhighways) initiatives.

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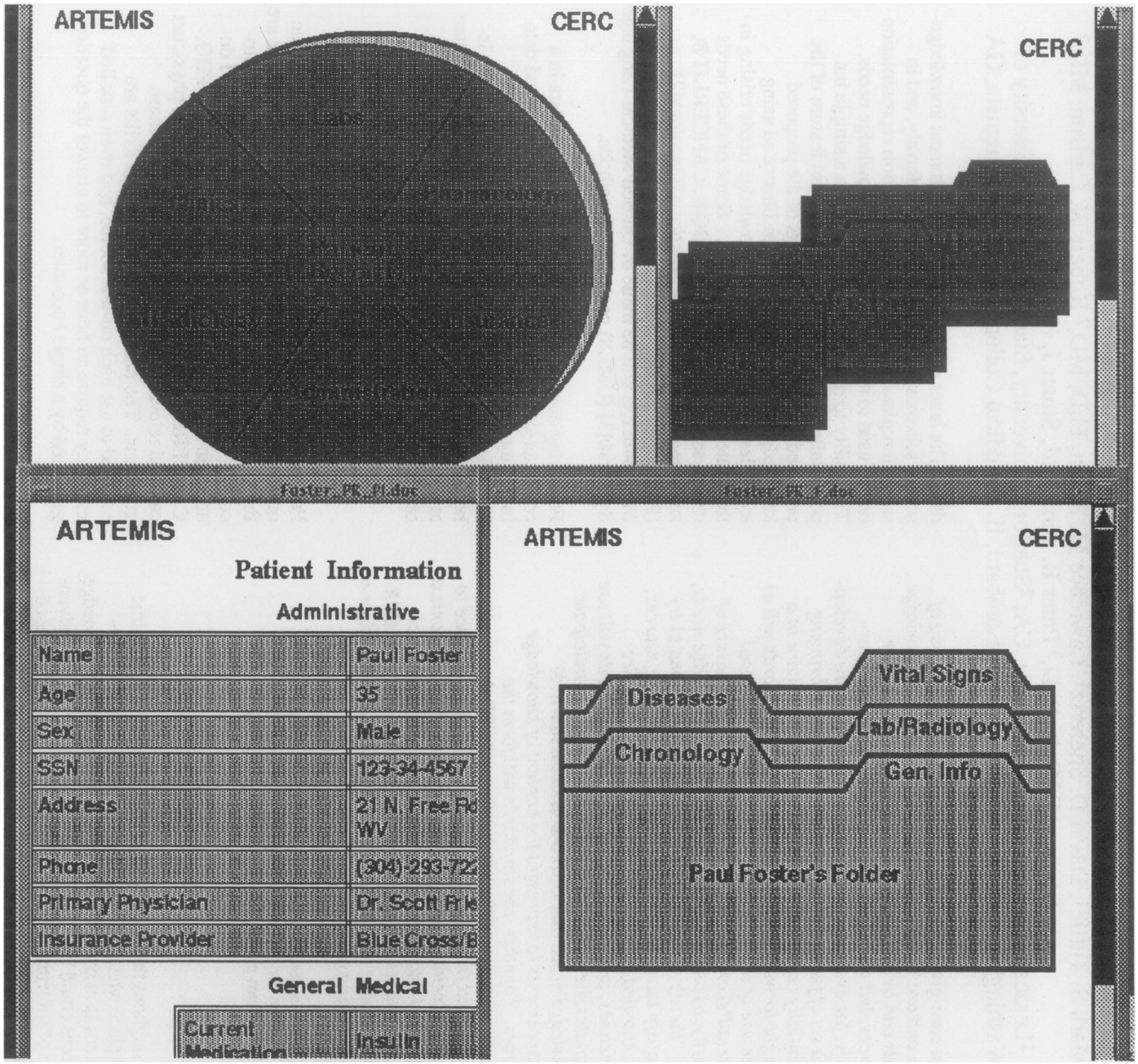

Figure 3. Multi-media hyper-linked patient records (conceptual view)